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Gallium-67 Scintigraphy and Intraabdominal Sepsis

Clinical Experience in 140 Patients with Suspected Intraabdominal Abscess

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In 140 patients with suspected intraabdominal abscess, studies were made using gallium-67 citrate and technetium-99m labeled radiopharmaceuticals. Gallium-67 scintigrams correctly localized 52 of 56 intraabdominal abscesses confirmed at surgical operation or necropsy. In an additional 20 patients in whom findings on scintigrams were abnormal, there were clinically established infections. Sixty-one patients in whom findings on scintigrams were normal were conservatively managed and discharged from the hospital; none proved to have an abscess. Four false-negative and three false-positive studies were recorded. Gallium-67 scintigraphy is a useful noninvasive diagnostic adjunct that should be employed early in the evaluation of patients with suspected intraabdominal sepsis.

LOCALIZATION of intraabdominal abscesses can prove a difficult and frustrating problem. Frequently the clinical impression of an occult abscess is not supported by findings on routine diagnostic studies including chest and abdominal roentgenograms, intravenous urography, abdominal ultrasonography and conventional liver-spleen scintigraphy. In these instances exploratory surgical operation is undertaken only after an extended work-up to locate the abscess and exclude other illnesses. The result may be extended periods of morbidity, protracted hospital stays and one or more operative procedures.

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Gallium-67 (^{67}Ga) localization in inflammatory lesions was initially recorded by Lavender and co-workers,[1] with subsequent clinical and experimental corroboration by other investigators.[2-5] The study reviews our experience with ^{67}Ga scintigraphy in a large group of patients with suspected intraabdominal abscess.

Methods and Material

Gallium-67 is a cyclotron produced radionuclide that decays by electron capture, has a physical half-life of 78 hours and produces gamma energies of 93, 184, 296 and 388 kilo electron volts (keV), which are suitable for imaging with either scintillation cameras or rectilinear scanners. The whole-body radiation dose is approximately 0.3 rads per millicurie which is well within ac-

TABLE 1.—*Primary Disease in 76 Patients with Confirmed Inflammatory Foci*

Primary Disease	Number of Cases	Primary Disease	Number of Cases
Diverticulitis	16	Trauma	5
Genitourinary tract	13	Malignancy	4
Regional enteritis	10	Ulcerative colitis	3
Appendicitis	8	Septicemia	2
Pancreatitis	8	Amebiasis	1
Peptic ulcer	6		

TABLE 2.—*Results of ^{67}Ga Scintigraphy in Patients with Confirmed Inflammatory Foci*

	Location			
	Abdomen	Pelvis	Subphrenic Space	Retroperitoneum
Confirmed by surgical operation or necropsy	16	8	18	10
Confirmed clinically	8	4	0	8
False-positive	2	0	1	0
False-negative	2	0	2	0

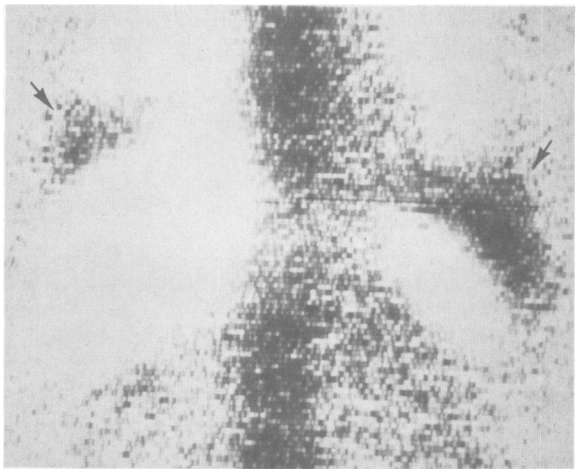

Figure 1.—Posterior 6-hour ^{67}Ga-^{99m}Tc subtraction scintigram (liver, spleen and lungs subtracted) showing bilateral subphrenic abscesses developing five weeks after a hemicolectomy for bowel cancer.

ceptable limits.[6] The ^{67}Ga for this study was supplied as a sterile and pyrogen-free citrate by New England Nuclear Corporation.

Technetium-99m (^{99m}Tc) decays with a six hour physical half-life emitting monoenergetic 140 keV gamma radiation. Technetium-99m sulfur colloid, ^{99m}Tc-human albumin microspheres and ^{99m}Tc-glucoheptonate were used as liver-spleen, lung and kidney imaging agents, respectively. These agents were prepared in the Nuclear Medicine Laboratory from commercially available kits (New England Nuclear Sulfur Colloid and Glucoheptonate kits, 3M Brand Human Albumin Microsphere kit).

All studies commenced four to six hours after the intravenous administration of 3 millicuries of ^{67}Ga-citrate. In many patients delayed scintigrams also were done at 24 and 48 hours postinjection. Since approximately 15 percent of an intravenous dose of ^{67}Ga is excreted via the intestine,[6] laxatives were administered before delayed studies in an attempt to reduce colonic activity. Appropriate liver-lung, liver-spleen or kidney scintigrams using 2 millicuries of ^{99m}Tc-sulfur colloid, 2 millicuries of ^{99m}Tc-human albumin microspheres, or 10 millicuries of ^{99m}Tc-glucoheptonate were obtained with the early ^{67}Ga study. Anterior, lateral and posterior images were obtained.

Both the Anger scintillation camera and rectilinear scanner were employed. The camera studies were done with either a Searle Radiographics Pho/Gamma III-HP, Nuclear Data Radicamera-60 or a General Electric Radicamera-II scintillation camera using the 184 and 296 keV photopeaks, a 20 percent window and a medium energy diverging collimator. The Nuclear Data camera was equipped with two pulse-height analyzer windows that provided the capability of counting both photopeaks simultaneously. Either the 184 or 296 keV photopeak was employed when using the General Electric or Searle Radiographics scintillation cameras. The 140 keV photopeak of ^{99m}Tc differs sufficiently from the photopeaks of ^{67}Ga so that combined studies using both radiopharmaceuticals are possible. The patient is maintained in the same position and single or double exposures, using window settings for ^{67}Ga and ^{99m}Tc respectively, are obtained on Polaroid film and magnetic tape. The scintillation cameras are interfaced to a Nuclear Data ND 812 computer.

Rectilinear studies were carried out with the 3-inch Searle Radiographics Pho/Dot scanner and the Raytheon 5-inch dual-probe whole body scanner. Range 1 (15-120 keV), 30 percent suppression and the 19-hole collimator were used with the Searle Radiographics scanner. When scanning with Raytheon electronic pulse-height analyzer subtraction, 30 percent contrast enhancement, 2:1 minification and medium-energy collimators were used. A 85-350 keV window was used when pulse-height analyzer subtraction was deemed unnecessary. Scan speed was adjusted to obtain a minimum information density of 600 counts per cu cm.

With electronic pulse-height analyzer subtrac-

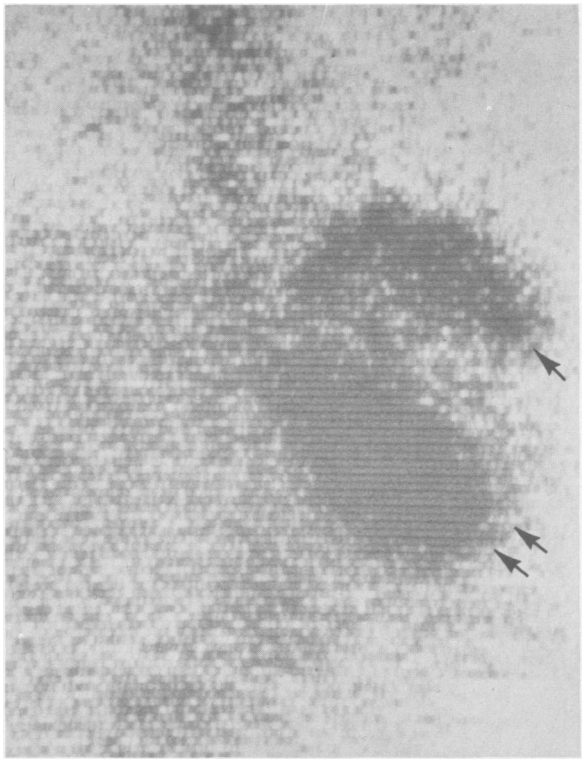

Figure 2.—Posterior 6-hour ^{67}Ga scintigram in a patient with pancreatitis **(double arrows)** and a left subphrenic abscess **(single arrow).**

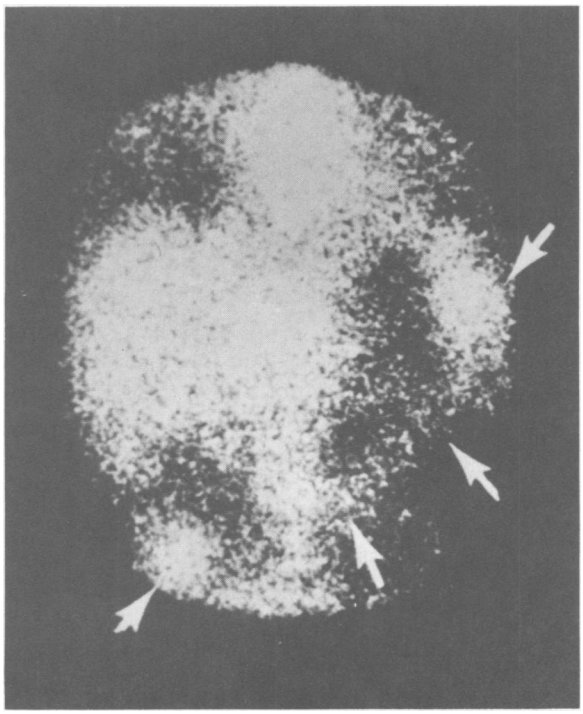

Figure 3.—Anterior 4-hour ^{67}Ga scintigram showing a left subphrenic abscess, fistula tract and right upper quadrant abscess two weeks after a splenectomy and partial bowel resection for abdominal trauma.

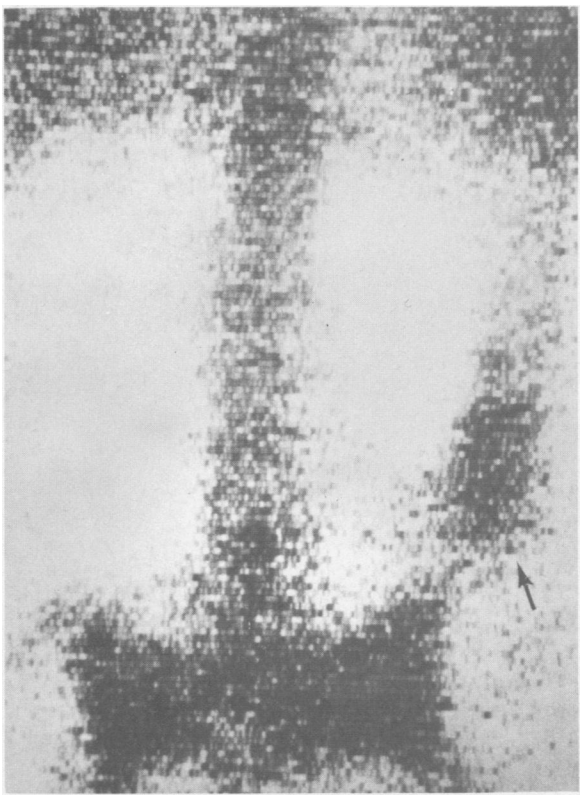

Figure 4.—Posterior 6-hour ^{67}Ga-^{99m}Tc subtraction scintigram (kidneys subtracted) showing a perinephric abscess that developed two weeks after a colectomy for ulcerative colitis.

tion technique, all signal pulses corresponding to both ^{67}Ga and ^{99m}Tc gamma interactions from the anterior or posterior probe are directed to both pulse-height analyzers. One pulse-height analyzer, by way of energy selection, permits the 184 and 296 keV photopeaks of ^{67}Ga to be recorded. The second pulse-height analyzer is adjusted to accommodate the 140 keV photopeak of ^{99m}Tc. Each pulse-height analyzer is normalized to 100 percent over the appropriate area. Two scintiscans are produced simultaneously. One represents the distribution of ^{67}Ga while the other represents the distribution of ^{67}Ga minus the distribution of ^{99m}Tc.

Results

This series is comprised of 140 patients with suspected intraabdominal abscess referred to the Nuclear Medicine Laboratory during the interval from January 1973 to January 1976. All patients had fever; most had a variety of clinical and laboratory abnormalities suggestive of infection. In many instances the possible site of involvement

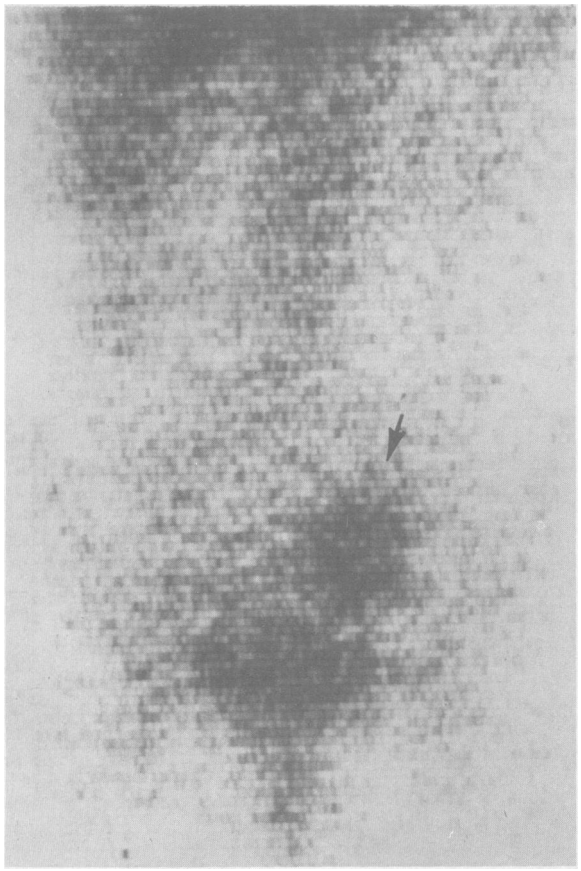

Figure 5.—Anterior 4-hour ^{67}Ga scintigram showing a chronic tubo-ovarian abscess in a patient with a fever of undetermined origin. Normal bladder activity is present below the abscess.

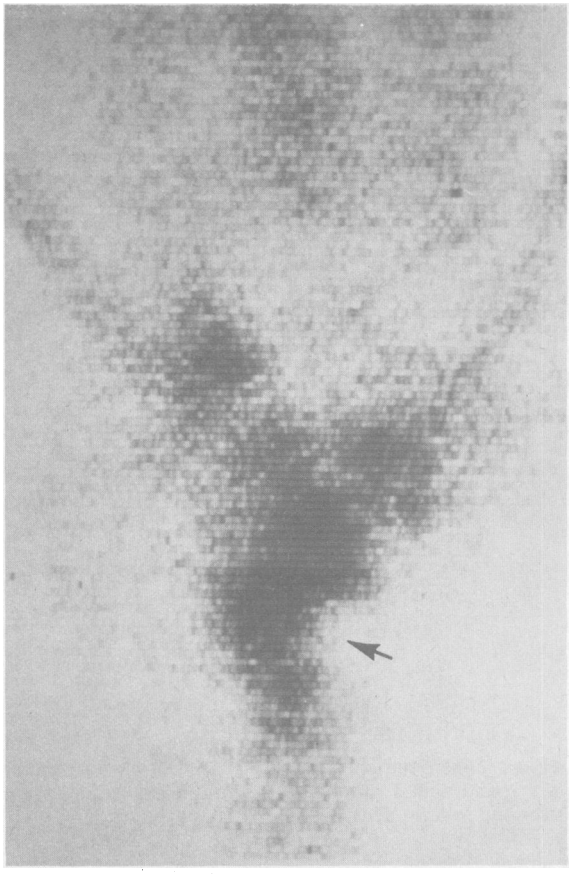

Figure 6.—Anterior 24-hour ^{67}Ga scintigram showing a deep pelvic paravaginal abscess that developed following pelvic trauma.

was either not evident or only suggested by routine diagnostic studies. In most patients signs of sepsis developed as complications of diseases, operations or injuries of the gastrointestinal or genitourinary tracts (Table 1).

The results of ^{67}Ga scintigraphy with respect to general location are summarized in Table 2. Patients with pyelonephritis were excluded from the group with retroperitoneal infections. Gallium-67 scintigrams correctly localized 52 of 56 deep abdominal abscesses confirmed by either surgical operation or necropsy. Examples are shown in Figures 1 through 7. An additional 20 patients with clinical evidence of deep abdominal infection and abnormal scintigrams were conservatively managed with antibiotics, which resulted in gradual defervescence and clinical improvement. In all likelihood, these latter cases represented ^{67}Ga localization in areas of diffuse inflammation rather than organized abscesses. In four of these patients repeat ^{67}Ga scintigrams carried out at intervals of three to six weeks showed resolution of the previous abnormality.

Sixty-one patients with fever and negative scintigrams were conservatively managed and discharged from the hospital. These studies had been obtained in patients with septicemia, in postoperative patients or in patients with predisposing gastrointestinal or genitourinary tract disease to rule out the possibility of an occult abscess. None of these patients proved to have an abscess.

Four patients with false-negative studies had surgically confirmed abscesses. The reason for the false-negative results is unclear though probably related to insufficient target-to-background ratios for abscess differentiation. Three false-positive studies were recorded. In retrospect, two of these represented errors in interpretation due to residual colonic activity. Although both had been negative on early scintigrams, they were subsequently judged abnormal on the basis of delayed studies. Purgatives had been contraindicated in both pa-

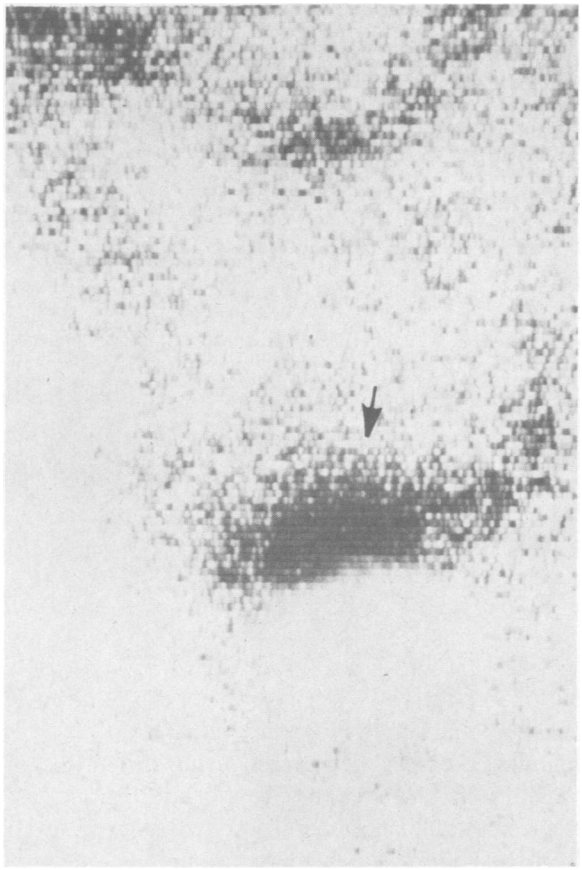

Figure 7.—Anterior 24-hour ^{67}Ga-^{99m}Tc subtraction scintigram (bladder subtracted) in a patient with diverticulitis and a peridiverticular abscess.

tients. The third false-positive study represented over-zealous interpretive error.

Discussion

Based on our experience, ^{67}Ga scintigraphy is warranted in patients with suspected intraabdominal abscess, particularly when other diagnostic modalities yield negative or equivocal results. Gallium-67 scintigrams not only localized 52 of 56 confirmed abscesses, but also proved instrumental in ruling-out infection in 61 patients originally thought to harbor occult infection. The low incidence of false-negative and false-positive results in this and other reported series[7,8] can be reassuring, particularly in postoperative patients in whom fever may develop for a variety of reasons. In addition, negative ^{67}Ga scintigrams in patients with evidence of sepsis strongly suggest that a localized focus is not present or that its size may be too small to be detected by other means.

The common practice in most laboratories is to delay ^{67}Ga scintigraphy for 24 to 72 hours after the intravenous injection to ensure optimal target-to-background ratios for abscess differentiation. Previous studies from this laboratory have shown this practice unwarranted due to the avidity of ^{67}Ga for inflammatory sites.[9,10] If early scintigrams are negative or questionable, delayed studies can then be obtained. To routinely delay ^{67}Ga scintigraphy in septic patients not only limits its clinical utility, but also contributes to prolonged patient morbidity.

Approximately 20 to 30 percent of an intravenous dose of ^{67}Ga-citrate is excreted by the kidneys,[6] with most of this occurring in the first 24 hours postinjection. After the first day the liver and biliary tract become the major route of excretion; therefore an additional advantage of early scintigraphy is the ability to image the abdomen without undue interference from colonic activity. Some bowel activity may be seen on early scintigrams though it is not nearly as pronounced as that present on 24 or 48 hour studies. When present, it is generally confined to the area of the cecum and right colon. Early scintigrams are particularly helpful in patients in whom cathartics are contraindicated.

The property of ^{67}Ga to localize in liver and spleen as well as in inflammatory foci can prove a problem in subphrenic abscess if target-to-background ratios are insufficient for abscess differentiation. This is of considerable import as the subphrenic space is the most common site of a postoperative abscess.[11] The combined study using ^{67}Ga-citrate and ^{99m}Tc-sulfur colloid is particularly helpful in this regard. The limits of the liver and spleen can be readily defined with ^{99m}Tc-sulfur colloid and the site of any abnormal ^{67}Ga localization outside these areas more accurately assessed. Combined studies using ^{99m}Tc-glucoheptonate to image the kidneys are helpful in cases of suspected perinephric abscess. In our experience, combined studies using the Raytheon rectilinear scanner with electronic pulse-height analyzer subtraction proved preferable to combined studies with the scintillation camera as it provided scintigrams that were easier to interpret.

The mechanism of ^{67}Ga localization in inflammatory foci has not been clearly elucidated. Suggested mechanisms include ^{67}Ga protein complexes accumulating about the inflammatory site[7] and the *in vivo* labeling of granulocytic leukocytes that migrate to the inflammatory focus.[12] A decrease in circulating granulocytes has correlated

with both a diminution in intensity and delay in onset of ^{67}Ga detection in experimental inflammation.[13]

In summary, ^{67}Ga scintigrams correctly localized 72 of 76 deep abdominal inflammatory foci. Gallium-67 scintigraphy is a useful noninvasive adjunct that should be employed early in the diagnostic work-up of a febrile patient with suspected intraabdominal sepsis.

REFERENCES

1. Lavender JP, Lowe J, Baker JR, et al: Gallium-67 citrate scanning in neoplastic and inflammatory lesions. Br J Radiol 44: 361-366, 1971

2. Hegasi T, Nakayama Y, Murata A, et al: Clinical evaluation of ^{67}Ga-citrate scanning. J Nucl Med 13:196-201, 1972

3. Blair DC, Carroll M, Carr EA, et al: ^{67}Ga-citrate for scanning experimental staphylococcal abscesses. J Nucl Med 14:92-102, 1973

4. Harvey WC, Silva J, Haines RS: Detection and delineation of abdominal abscesses in rabbits with ^{67}Ga. Radiology 107:681-682, 1973

5. Littenberg RL, Taketa RM, Alazraki NP, et al: Gallium-67 for the localization of septic lesions. Ann Intern Med 79:403-406, 1973

6. Edwards CL, Hayes RL: Scanning malignant neoplasms with Gallium-67. JAMA 212:1182-1190, 1970

7. Blair DC, Carroll M, Silva J, et al: Localization of infectious processes with Gallium citrate Ga^{67}. JAMA 230:82-87, 1974

8. Kumar B, Coleman ER, Alderson PO: Gallium citrate Ga^{67} imaging in patients with suspected inflammatory processes. Arch Surg 110:1237-1242, 1975

9. Hopkins GB, Mende CW: Gallium-67 and subphrenic abscess —Is delayed scintigraphy necessary? J Nucl Med 16:609-611, 1975

10. Hopkins GB, Kan M, Mende CW: Early ^{67}Ga scintigraphy for the localization of abdominal abscesses. J Nucl Med 116:990-992, 1975

11. Sherman RT: Infections, *In* Schwartz SI (Ed): Principles of Surgery. New York, McGraw-Hill Book Co Inc, 1969, 136-151

12. Burleson RL, Johnson MC, Head H: In vitro and in vivo labeling of rabbit blood leukocytes with ^{67}Ga-citrate. J Nucl Med 15:98-101, 1974

13. Gelrud LG, Arseneau JC, Milder MS, et al: The kinetics of 67 Gallium incorporation into inflammatory lesions: experimental and clinical studies. J Lab Clin Med 83:489-503, 1974

Correcting Inverted Nipples

I feel that there is a way that we can correct this abnormality [inverted nipples]. First, you instruct the girl to make an imaginary cross on her breast, using the nipple as the center part of the cross and making the arms of the cross at a 90-degree angle. In other words, there's a vertical line and a horizontal line meeting over the nipple. Then, she presses into the breast tissue adjacent to the areola and extends pressure laterally along the arms of the cross, first vertically and then horizontally (preferably done by the girl after a bath or a shower when the tissue is softer). She will find that over a period of time the inverted nipple will gradually become everted. Now after some eversion has occurred, it is important to grasp the partially everted nipple and pull it out further. If this is done repeatedly over a period of time, it does correct the inversion. . . . However, I must quickly add that even though the inversion has been corrected, I cannot guarantee that it would be satisfactory for breast feeding. However, I urge that this approach be tried.

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